OPTICAL TORQUE.[1]

II.

IT will be convenient here for me to refer to some researches, not yet published, which I have made, as to the various orders of transition tints, with the view of ascertaining which of them is the most sensitive—which of them, in fact, shows the greatest change of tint for the smallest amount of rotation. Reference to the diagram on the wall displaying Newton's tints will make clear what I mean by the transition tints of the several orders. The tints obtained from quartzes of varying thicknesses may be considered as approximately identical with the tints of Newton's rings, provided we remember that the air-film which gives any particular tint in Newton's rings is about 1/300,000 part as thick as the quartz which yields the corresponding tint in the polariscope. Better far than any painted diagram, because richer and purer, are the tints now thrown upon the screen by introducing into the field a thin wedge of selenite, displaying the whole of the colours of the first three orders of Newton's scale. You will notice the successive recurrence of purple tints, both in the colours seen in the bright field, and in those seen in the dark field.

First I will show you the transition tints of the first and second orders in the bright field. That of the second order is much less intense than that of the first; and yet it is very sensitive, turning to a green tint whilst the first order purple has only turned to a blue. On the other hand, with reversed rotation of the analyzer it turns to red less rapidly than does the tint of the first order.

Next I take the transition tints of orders I., II., and III. in the dark field. These, though arranged, by means of superposed half-disks of "quarter-wave" plates, to be optically equivalent to biquartzes of two rotations, are really built up of selenite and mica. You will notice how the tint of order I. surpasses in sensitiveness both the others. I cannot here show you on the screen the means by which I have compared the tint of order I. in the dark field with that of order I. in the other set. Suffice it to say that I find the tint of order I. in the dark field—corresponding to 7·5 millimetres thickness—more sensitive than that of order I. in the bright field, which corresponds to 3·75 millimetres thickness.

A method which was at one time supposed to be more precise, was that of placing a spectroscope (or its prism) in front of the analyzer, and watching the motion along the spectrum of the interference bands which are then seen. My three pieces of crystal remain. I introduce a slit in front of them, also a single film of quarter-wave mica, and then a prism to give the spectrum. This prism (Fig. 9), by the way, is a new sort of direct-vision prism, having a single very wide-angled prism of Jena glass inclosed in a cell with parallel ends containing cinnamic ether (first recommended by Wernicke), a liquid which has the same mean refractive power, but widely different dispersion. It is preferable to bisulphide of carbon in several respects: first, its odour is a delicate reminiscence of cinnamon; it is barely volatile; and it is whiter than bisulphide. This prism, which is shown also in plan in Fig. 10, was constructed for me by Messrs. R. and J. Beck. It will be seen that the dark bands in the spectrum are nebulous and ill-defined. It is idle to hope to secure accuracy by turning the analyzer until they shift along to a definite point. And there is no advantage in using the higher orders of tints which give more bands; for, though the bands are certainly better defined, their progression across the spectrum for a given amount of rotation is proportionally smaller.

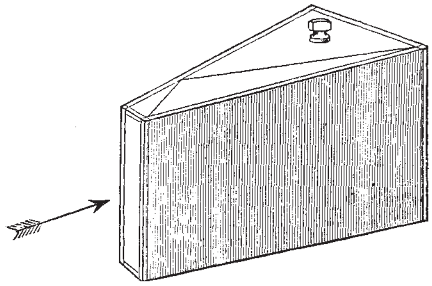

FIG. 9.—Direct-vision prism for projection of spectrum.

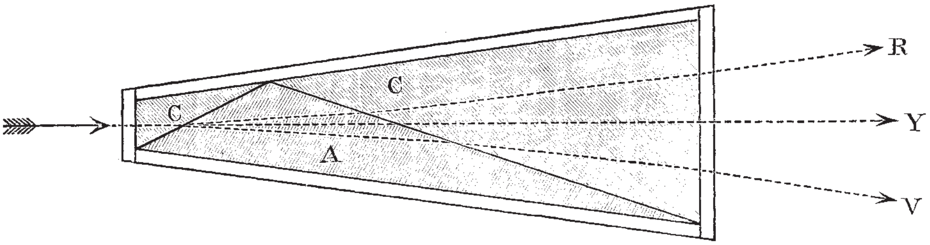

FIG. 10.—Direct-vision prism. A, wide-angled prism of Jena glass; C, cinnamic ether.

Another suggestion, due to Sénarmont, is to use two sets of superposed wedges of right- and left-handed quartz. Such you now see before you. Instead of starting with extinction you start with coincidence between the upper and lower set of bands. Any rotation of the light shifts the bands, one set moving to left, the other to right. By turning the analyzer through an equal angle coincidence is again obtained.

Another method, used by Wild in his polaristrobometer, is to produce the phenomenon known as Savart's bands (due to the introduction of two crossed slices of quartz cut at a particular angle). The bands disappear when the analyzer is set in a particular direction. Anything that twists the plane of polarization causes them to reappear; but they again fade out when the analyzer is turned through an equal angle.

There is yet another method in polarimetry, due to Soleil, in which the optical torsion due to the sugar is counterbalanced or compensated by introducing a pair of sliding wedges of quartz of the opposite rotation. This device is known as a "compensator." By sliding the quartzes over one another a greater or less thickness of quartz is introduced at will. But I must not stop to illustrate this elegant device.

Yet one other method must be mentioned, and this is certainly the most preferable. It consists in aiding the eye to recognize with precision a particular degree of extinction, by the device, first suggested in 1856 by Pohl, of covering a portion of the visible field with something which slightly alters the initial plane of polarization, so that complete blackness is not obtained at once over both parts of the field. A common device is to cover half the field with a slice of some thin crystal—mica or quartz—so that only one half can be perfectly black at any instant. As an example, here is the field covered half over with a plate of mica of the thickness known as half-wave. The result is that when one half of the field is black the other is light. Adjust the analyzer now to equality. Now introduce something that rotates the light—say a tube with sugar solution in it. At once the balance is upset, and I must, in order to get equality, turn my analyzer.

Of the same class are the polarimeters with special prisms made in two parts slightly inclined to one another. The earliest of these was devised by the late Prof. Jellett, of Dublin, and has been followed by imitations of the same plan by Cornu, by Lippich, and by Schmidt and Haensch. The beautiful "shadow polarimeter," by the latter firm, which I here exhibit, has the divided prism, and a quartz compensator.

I have suggested two simpler methods of accomplishing the same end. In the first place, I have proposed to use *twin-prisms*. These are made on a plan suggested to me by finding that Mr. Ahrens's method of cutting calc-spar for prisms was admirably adapted for making such prisms, either with wide or narrow angles between the respective planes of polarization in the two parts of the visible field. Two such twin-prisms, one with 90°, the other with 2½°, between the prisms, are here on the table. In the second place, I have essayed a polarimeter, an example of which is before you, in which an arrangement of twin-mirrors (each set at the polarizing angle, but slightly inclined to one another) is made to yield a half-shadow effect.

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[1] A Discourse delivered at the Royal Institution, May 17, 1889, by Prof. Silvanus P. Thompson. Continued from p. 235.

Before I leave the subject of quartz I must refer to the famous mathematical theory of Fresnel, who endeavoured to explain its action upon light by supposing that the plane-polarized wave on entering it is split into two waves, consisting of oppositely circularly-polarized light, which traverse the crystal with different speeds. On emerging they recombine to form plane-polarized light, the plane of which, however, depends on the retardation of phase between the two components. I here introduce a mechanical model to illustrate one of the points in this theory—namely, the recombination of two circular motions to form a straight-line motion. These two disks (Fig. 11), which turn in opposite senses, but at equal rates, represent two circularly-polarized beams of light. The linkages, which connect two pins on these disks, compound their motions at the central point, P, which executes, as you see, a straight line. But now, suppose one of these circular motions to be retarded behind the other, an effect which I can imitate by shifting one of the pins to another position on the disk. Still the resultant motion is a straight line, but it is now executed in a direction oblique to the former. In other words, its plane has been rotated. Of course this model must not be taken as establishing the truth of Fresnel's ingenious theory: it is at best a rough kinematical representation of it.

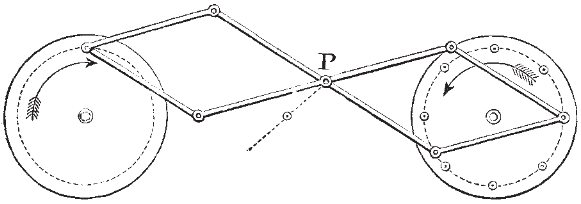

FIG. 11.—Model illustrating recomposition of rectilinear motion from two opposite circular motions.

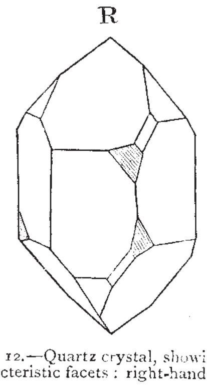

FIG. 12.—Quartz crystal, showing characteristic facets: right-handed.

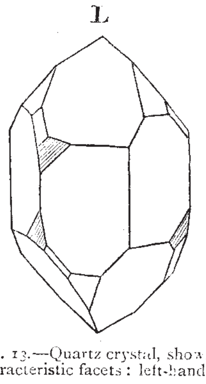

FIG. 13.—Quartz crystal, showing characteristic facets: left-handed.

We have, however, the puzzling fact still to account for that there should be two kinds of quartz crystals, right- and left-handed. Sir John Herschel first showed that natural crystals of quartz themselves often indicated their optical nature, by the presence of certain little secondary faces or facets which lay obliquely across the corners of the primary faces. These are indicated in the diagrams (Figs. 12 and 13), and may be seen in two of the specimens of quartz crystals which lie upon the table. The largest of these is right-handed. The wider generalizations of Pasteur, respecting the crystalline form of optically active substances, show that those substances which exercise an optical torque, whether as crystals or in solution, belong to the class of forms which the crystallographer distinguishes as possessing non-superposable hemihedry. In other words, they all show *skew symmetry*, as if in the growth of them they had been built up in some screw-fashion around an axis, and must therefore be either right-handed or left-handed screws. By piling up a number of wooden slabs in skew-symmetric fashion, I am able roughly to illustrate (Figs. 14 and 15) the difference between the right-handed and the left-handed structure. It is a curious fact, if I am rightly informed, that down to the present date the only substances possessing this skew symmetry are natural substances; that those which the chemist can produce by artificial synthesis are all optically inactive. It is perhaps equally significant that as yet no inorganic substances have been found which will in the liquid state rotate the light. This appears to be a property possessed solely by certain compounds of carbon. Quartz fused in the blowpipe or dissolved in potash shows no trace of rotatory power.

Yet we can have little doubt that this property is bound up in the yet unravelled facts of atomic and molecular structure. In the case of the liquids, such as turpentine and sugar solution, there must be some skew symmetry in the grouping of atoms in the molecule to produce the result. In the case of quartz, there must be a skew in the building of the molecules—there must, to borrow a phrase from the architect, be an oblique *bonding* of the minute bricks of which its transparent mass is builded. Though we cannot even rebuild it from its solution, we know this must be so, for we can reproduce all the optical phenomena which it exhibits by an actual skew building of thin slices of another non-rotatory crystal. Here is an artificial object (I built it myself) constructed on Reusch's plan, from sixteen thin slips of mica built up in staircase fashion—right-handedly—one above the other, and set symmetrically at equal angles of 45° to one another, the whole set making a cork-screw of two complete turns. In the lantern it behaves just as a quartz of about 9 millimetres thickness would do. It even gives tolerably perfect rings, as quartz does, when viewed by convergent light.

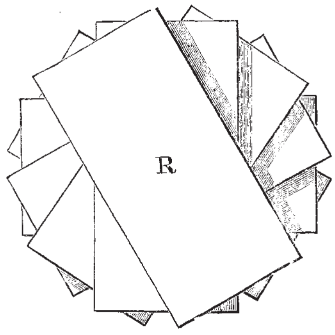

FIG. 14.—Skew-symmetrical arrangement: right-handed.

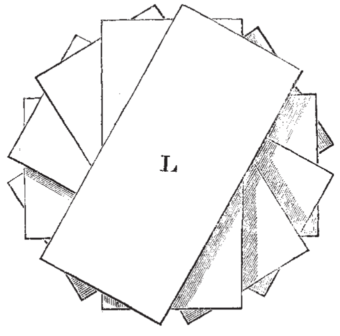

FIG. 15.—Skew-symmetrical arrangement: left-handed.

I must now pass hastily onwards to the great discovery of Faraday. Here (Fig. 16) is a magnetizing coil of wire, M, having about 8300 turns, and enclosed in an iron jacket. When it is traversed by a powerful electric current from the dynamo machine, it produces an intense magnetic field along its axis. In this axial position lies a bar of heavy glass, not quite so dense as that which Faraday himself used, but nearly so. The bar lies along the line of light from our lantern, but the polarizer, P (the Ahrens reflector, Fig. 7), and analyzer, A (the Ahrens triple spar prism, Fig. 6), are crossed, so that here is the dark field. On turning on the current, light is at once restored, being twisted to the right when the current circulates right-handedly. To measure the rotation, I must turn the analyzer; and now I find that, owing to the greater rotation of blue waves than of red, complete extinction does not occur. Introducing a half-shadow plate, and using coloured glasses, it is very easy to verify the greater amount of rotation for blue light, and to show that reversing the current reverses the rotation. You will perhaps better understand it if I use (as in Fig. 16) the 24-ray star, S, which I have previously employed. It is now obvious to you that there is a large rotation—over 50° in fact—which is reversed when I reverse the magnetizing current. We have thus repeated the fundamental experiment of magneto-optics. But now we meet with another consideration. Reflect that the circulation of current, if it be taken as right-handed when regarded from one end of the coil, will be left-handed when regarded from the other end of the coil. This is, therefore, no case of skew symmetry: it clearly indicates that something is going on in the glass which tends to twist the light quite irrespective of which way the light enters.

The next magneto-optic phenomenon is that discovered by Dr. Kerr, of the rotation of the plane of polarization by reflection at the surface of a magnet. To observe this at all requires good apparatus and a keen eye. So far as I am aware, it has never been projected on the screen. If I can succeed in doing so, it will only be because I have special means of the most favourable character for so doing. We withdraw the bar of heavy glass from the coil, and replace it (Fig. 17) by an iron core polished at its coned end. This will be intensely magnetized when the current is turned on.

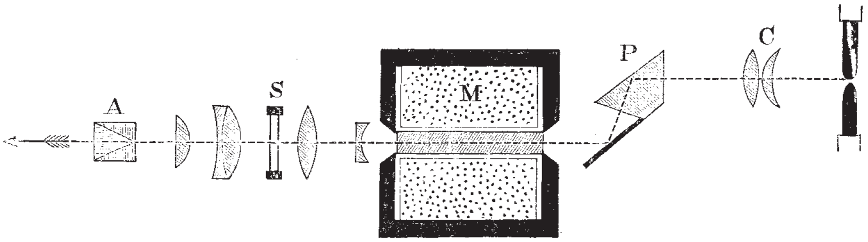

FIG. 16.—Projection of magnetic rotation of plane of polarization. C, condensing lenses; P, reflecting polarizer; M, magnetizing coil surrounding bar of heavy-glass; S, mica disk of twenty-four rays; A, analyzer (Ahrens's triple prism).

Now we must throw the beam of light obliquely down the hollow of the coil, polarizing it by one of my improved Nicol prisms, P, as it goes down. After reflection it is focussed by a lens which sends it through the analyzing prism, A. You see the dim spot of reflected light upon the screen. Now for the current: "on," "off," "on," "off." Reversing its direction ought to double the amount of torsion.

Whilst Mr. Thomas is making the needful arrangements for the next experiment, I may mention that it was found by Kerr that the effect was approximately proportional to the magnetic induction through the iron. I have myself tried some further experiments: for example, using a bar of lodestone instead of an iron core. The light reflected from lodestone is also twisted. I should expect the ferro aluminium alloy which Sir H. Roscoe showed us a fortnight ago to do the same thing, because that alloy is, as I have found, susceptible of magnetization. But I should not expect manganese steel to rotate the light, because of its singularly non-magnetizable nature.

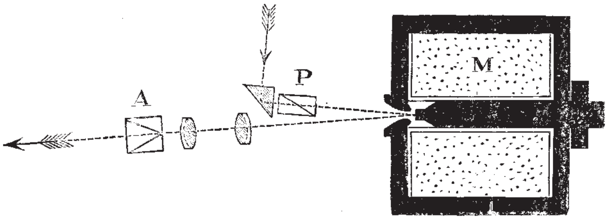

FIG. 17.—Apparatus for projecting rotation of plane of polarization by reflection at pole of magnet. P, polarizer; M, magnetizing coil with coned iron core; A, analyzer.

The experiment of Kundt, transmitting polarized light through a thin transparent film of iron, magnetized normally whilst the light is passing through it, is another difficult of repetition before an audience. The small disks here are covered with films of iron, kindly prepared for me by Mr. Crookes, by squirting them electrically in a high vacuum. But the thin ones barely transmit enough light to make the observation of the effect possible even to the solitary observer. I have observed the effect projected on the screen, using this very coil and these transparent mirrors. It requires, however, an absolutely dark room, and is at best so faint that it would be hopeless to attempt to show it to a large audience. Prof. Kundt has not only observed similar rotations in other magnetic films of nickel and cobalt, but has even shown that the degree of rotation of the light is proportional not to the magnetizing force, but to the resulting magnetic induction. This is a result of utmost importance in considering the theory of the phenomenon. He has further shown that, whereas the magnetic rotations in elementary bodies, whether magnetic or diamagnetic, are in the same sense as that in which the current circulates, the magnetic rotations in compound magnetic bodies, such as a solution of sulphate of iron in water, are in the opposite sense.

These experiments with transparent mirrors of iron raise interesting speculations as to the probable nature of a transparent magnet, if such there could be. It is one of the cardinal points of Maxwell's celebrated electro-magnetic theory of light, that the better a body conducts electric currents, the greater is its tendency to absorb light and become opaque. Now, suppose it were possible to obtain a substance such as to possess greater electric conductivity in one direction than in another, such a substance ought to absorb those vibrations of light which are executed in the direction of the greater electric conductivity more than those in the direction at right angles. In other words, such a substance ought, like the tourmaline, to polarize light by absorption. Now, since the researches of Sir W. Thomson in 1856, we have known that the electric conductivity of iron is altered in the direction of the magnetic lines of force, when it is powerfully magnetized. More recently it has been discovered—I myself observed it in tinfoil, and announced the discovery to the Physical Society a few days before the announcement of the same fact by Righi—that non-magnetic metals alter their resistance in the magnetic field. Notably so do bismuth and tellurium. I had therefore conceived it possible that a film of iron or possibly of tellurium, if strongly magnetized in its own plane, might exhibit polar absorption and act like a tourmaline. Unfortunately, if the effect exists it is so faint as to be yet undiscovered, though I have made many efforts to find such. I have further tried to obtain a similar result by making a transparent magnet out of a film of magnetic oxide of iron, precipitated chemically. In this too I have not succeeded. I have tried to precipitate a transparent film of magnetic oxide in the midst of a transparent jelly. And I have mixed particles of precipitated oxide with melted gelatine so as to get a film. In this way I hoped to get, by placing the preparation in a strong magnetic field, a sort of magnetic structure which would operate upon waves of light. That such a task was not hopeless was shown by two facts: first, that many mere vegetable and animal structures can act as polarizers; and second, that a mere film of paint, such as indigo, can, if a proper mechanical drug is given to it so as to produce structure, also act as a polarizer.

The film of indigo-carmine which I have here, acts nearly as strongly, though not quite as evenly, as a tourmaline slice, and costs but a fraction of a penny.

Well, my films of jelly enclosing particles of magnetic oxide of iron do faintly act on polarized light; but their action is not as marked as that of films of jelly inclosing actual small scraps of iron. This film, when placed across the poles of this electro-magnet, between two Nicol prisms at 45°, shows an action when the magnet is turned on, as you see by the way in which it flashes into light in the dark field. When the jelly is fresh, and of the proper consistency, the action is very strong, but with the rather dry sample before you I fear we can only call the effect a *succès d'estime*.

Incidentally, in the course of these experiments on magnetic films, I came across a new magnetic body unknown hitherto, I believe, to the chemist—namely, a magnetic double oxide of cobalt and iron—a ferroso-cobaltic oxide, I think—a black powder, a sample of which I have here.

It also occurred to me, as a matter of speculation, that if I could strongly magnetize a crystal of ferrous sulphate or nickelous sulphate, whilst viewing it by convergent polarized light I might find some interesting phenomena, which should, if they existed, show some sort of a relation between the direction of the optic axis and that of the lines of the magnetic field. I thought that a longitudinal magnetization might possibly set up a rotatory phenomenon like that in quartz in so far as to disturb the central field between the arms of the black cross; however, not by the most powerful magnetizing could I discover any such effect. Again, I thought that by magnetizing transversely to the optic axis I might possibly succeed in turning the uniaxial crystal into a biaxial, or producing by magnetism an effect resembling the action of heat on crystals of selenite. Owing probably to the small depth of any crystals that can be obtained, I have failed so far to obtain any such effect, though I am convinced that it must exist.

An effect precisely analogous to the magnetic effect which I vainly sought has, however, been lately discovered by Prof. Röntgen. I sought a distortion of the optic axis by transversely magnetizing, and I sought it in crystals of sulphate of nickel: he has found a distortion of the optic axis by transversely electrifying, and he has found it in crystals of quartz.

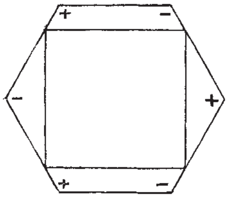

Fig. 18.

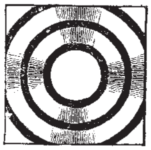

Fig. 19.

Suppose a piece of a quartz crystal is cut as a square prism, its long faces being principal planes of section respectively parallel to and at right angles to two of the natural faces of the hexagonal prism. Fig. 18 shows the form of the portion cut. The + and − signs in this figure refer to the pyro-electric poles of the crystal. Such a piece viewed by convergent light shows the usual rings and black cross with a coloured centre (Fig. 19). If now two opposite faces be covered with tinfoil, and the crystal be electrified transversely, the rings are distorted into lemniscates, the direction of the distortion changing with the sign of the electrification. It is necessary to use a red glass, or still better sodium light, to observe the changes in form on reversing the sign of the charges. Figs. 20 and 21, 22 and 23, show the changes of form, but these sketches grossly exaggerate the effects. As you see upon the screen, when the charges imparted by this fine Wimshurst machine are rapidly reversed, there is a decided distortion of the rings, but it is small in amount.

Returning to the phenomena of the rotation impressed by magnetism on polarized light, I may point out that the torque which a magnetic field exerts on the light-waves appears to be really an action upon the matter through which the light-waves are passing. It is as though the magnetic field were really a portion of space rotating rapidly on itself, or perhaps as though the ether were there rotating, and that this rotation in some way dragged the particles of matter along with it. It has long been supposed necessary, in order to account for the refractive and dispersive properties of transparent bodies, to consider that their particles are in some way concerned in and partake of the vibrations going on in the ether within them or between their molecules. It is impossible to explain the phenomena of magneto-optic rotation by the supposition that any skew structure is imparted to the medium; for these phenomena, unlike those of quartz, do not exhibit skew symmetry. There seems to be no other way of explaining the magneto-optic torsion of light than by supposing that the molecules of matter in the magnetic field are actually subjected to rotatory actions; as indeed was suggested long ago by Sir William Thomson.

However, there is room here not only for speculation but for experiment. Some day, when facts enough have been collected, we shall be ready to build thereon the wider generalization which at present seems to escape us.

So far we have been applying an optical torque to previously polarized light, and producing a torsion of it. It remains for me yet to describe the means by which, in the hands of Prof. Abbe and Prof. Sohncke, it has been demonstrated that natural, non-polarized light is actually rotated when subjected to an optical torque.

The way of doing this is to make use of the principle of interference. Here is a slit from which a narrow beam of light-waves issues. At a point a little distance away is a Fresnel's biprism which splits up the light (without polarizing it) into two beams, just as if we had two slits or sources of light. These two beams pass along, and meet upon this distant screen, and give us—what? A set of interference fringes, having a bright line down the middle, because this part of the screen is exactly equidistant from the two sources of light.

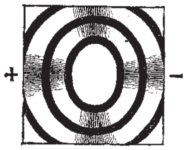

Fig. 20.

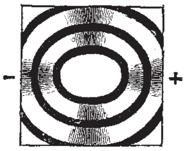

Fig. 21.

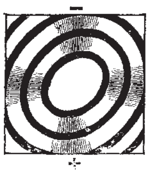

Fig. 22.

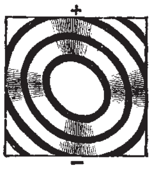

Fig. 23.

But these dark interference fringes that lie right and left can only exist because, in the first place, the vibrations have travelled unequal paths differing by an odd number of half wave-lengths; and secondly, because (owing to the method adopted of using two images of one slit) the phases of the emitted waves from the two sources are identical.

This being so, let us now introduce across the two interfering beams of light a special biquartz, made of right- and left-handed quartz of only 1·88 mm. thick. This will rotate—*if it rotates natural light at all*—the yellow light in one beam 45° to the right and that of the other beam 45° to the left. The angles will be a little more for green and blue, a little less for red and orange. Consequently we shall not get quite a perfect result for all kinds of colours. But for the main body of the light the result is this: that because the two beams have had their respective vibrations turned so that, whatever their primitive positions, they are now at right angles to one another, they cannot interfere. In other words, if it be true that the quartz rotates natural light, the interference bands will die out. [Experiment shown.]

Here I have the light passing through the biprism only, and giving us this narrow series of interference bands. You must notice carefully—with opera-glasses if you have them—the narrow bright and dark stripes. Now I shift this little diaphragm so that the light passes through the biquartz as well. Instead of sharp interference bands we have merely a dull line of nebulous light. The disappearance of the fringes proves that quartz does twist the not-previously-polarized waves of light.

That the magnetic field can also exert a magnetic torque on non-polarized light is readily proved, at least when one already has the biquartz. Two strips of heavy-glass of exactly equal length and similar quality, such as those I hold in my hand, must be introduced in the respective paths of the two beams: and one at least of them must be surrounded by a magnetizing coil. The biquartz has wiped out the interference fringes; but on magnetizing one of the two pieces of heavy-glass, or on magnetizing the two in opposite senses, the interference bands can be made to reappear. It is in this way that Prof. Sohncke's experiment—hardly suitable for a lecture theatre—was performed. It is in this way that we establish upon an experimental basis the fact that light itself, and not merely the plane of its polarization, experiences an optical torsion when subjected to those forces which, whether crystalline, molecular, or magnetic, exert upon it an optical torque.

BABYLONIAN ASTRONOMY.[1]

II.

THE year—that is, the period bringing back the recurrence of the seasons—is not a primitive means of dividing time, but the result of many observations. The simplest way of marking time is by seasons, and the system is still employed by some savage nations in Africa. A season does not correspond to one year, and more than one may be in a year; seasons, however, generally correspond to the year period. As to the division of the year, it must have varied according to the climate and region, but the simplest is by ten, as ten is the most common dividing number, and such was the one originally adopted by the Semites and Egyptians. This year of ten months, or rather ten parts, has left traces among the Semites and in classical authors. The Babylonians assimilated their first ten kings to the ten parts of the year. At Rome, we are told that the year before Numa Pompilius was composed of ten months only.

A year of ten lunar months is impossible, for after two or three of such periods it would no longer correspond with the seasons. We find, therefore, that the ten parts of the year were composed of thirty-six days distributed in four periods or weeks of nine days. This last division was not, however, official: the days of each of the ten divisions of the year were merely numbered from one to thirty-six; it was at a later date that the days received names from the protecting gods attributed to them.

It is to be noticed that in Egypt the months had no special names; the year was divided, after the reform of the calendar, into three seasons of four months of thirty days, called first, second, and so on, of the season to which they belonged. Popular names were attributed to them afterwards, taken from the religious festivals, but they do not appear in the texts before the Ptolemaic period. The like took place among the Semites: the months were called first, second, third, and so on, but were not distributed into seasons. It was only after the Akkadian invasion that the other names, Nisan, Tyyar, &c., were adopted, and the eighth month never lost its numerical name. In the astronomical omen tablets the primitive nomenclature by numerical order was often preserved.

It is still uncertain at what time the old calendar of ten divisions of thirty-six days was reformed into one of twelve months of thirty days. The change was due to the desire to measure the time by the appearance of the moon. This reform may be due to the influence of the Akkadians, who made the conquest of Babylon about 7000 B.C. These people had a lunar calendar composed of thirteen months of twenty-eight days, giving, therefore, a year of 364 days. It was no doubt more accurate than the Semitic calendar, but the Akkadians adopted their subjects' calendar. The deficiency with the normal solar year of 365 days was made up by means of a supplementary month placed irregularly by the priests when they thought it necessary. That is why we find various intercalary months, and why, in some cases, as late even as Nebuchadnezzar the Great, they occur in three successive years. To make up the deficiency the Babylonians had also a supplementary day called the "heavy 21st," which could be inserted in any month before the normal 21st. We find the mention of such supplementary days in several consecutive months.

The Akkadians, before invading Babylonia, divided their month into four parts or weeks of seven days each. This division had, however, nothing to do at first with the planets, to which the days were assimilated only at a later date. The Akkadians looked on the planets as evil spirits disturbing by their irregular motion the harmony of heaven; and, as evil spirits were the chief objects of their worship, they naturally attributed to each day of the week the name of a planet. When the Akkadians adopted the Semitic month of thirty days, the week of seven days was naturally abandoned in common use, but it was retained for religious purposes with some modification, a new series of four weeks commencing with each month. The Semites rejected the Akkadian names of the days of the week, though they preserved the symbolism attached to them, as is shown by the seven tablets buried under the foundation-stone of Khorsabad.

Our names of the days of the week are derived from the Akkadian assimilation of these days to the planets. There is no doubt as to the order in which the planets were assimilated to the names of the days, if we compare them with the colours of the walls of Ekbatana built by a Medic tribe, which preserved the primitive religion of the Akkadians, and also with the tablets of Khorsabad. The following table will show the correspondence:—

Names of the days and planets.	Colours of the walls of Ekbatana.	Materials of the tablets of Khorsabad.
1 Sunday (the Sun)... ...	Gold ...	Gold
2 Monday (the Moon) ...	Silver ...	Silver
3 Tuesday (Mars)	Orange ...	Copper
4 Wednesday (Mercury) ...	Blue ...	Tin
5 Thursday (Jupiter) ...	Red ...	Iron
6 Friday (Venus)	Black ...	Basalt
7 Saturday (Saturn)... ...	White ...	Limestone

Iron, corresponding to Thursday, or Jupiter, is represented by a red colour, no doubt on account of the rust, which is red. And we must not be surprised to see Venus represented symbolically by black, for Vesper or the Evening Star is really the *dusky*.

This proves that the week of seven days, which is found all over Asia and Europe, spread, not from Babylonia, but from the country whence came the Akkadians.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE summer meeting of this Institution was held in Paris last week under the presidency of Mr. Charles Cochrane.

The papers offered for reading and discussion were a description of the lifts in the Eiffel Tower, by Mr. A. Ansaloni, of Paris, supplemented by the results of working to date, communicated verbally by Mr. Gustave Eiffel, President of the Société des Ingénieurs Civils; the rationalization of Regnault's experiments on steam, by Mr. J. Macfarlane Gray; on warp-weaving and knitting without weft, by Mr. Arthur Paget; on gas-engines, with description of the Simplex engine, by Mr. E. Delamare-Deboutteville; on the compounding of locomotives burning petroleum refuse in Russia, by Mr. T. Urquhart; and description of a machine for making paper bags, by Mr. Job Duerden.

In the discussion of the first paper, which, as its title shows, was mainly technical in character, the interesting meteorological circumstance of the Eiffel Tower acting as a thunder-cloud discharger was referred to; clouds laden with electricity having passed quietly over the region of the tower, which previously and afterwards flashed with lightning. It was also pointed out that the perpendicularity of the building is not affected by temperature variations, nor by any wind pressure hitherto recorded.

We have not received a copy of the paper by Mr. Gray, who reserves the right of reproducing it, but from the syllabus of papers published by the Institution of Mechanical Engineers, it may be stated that Mr. Gray proposes a new unit of heat, which he compares with the ordinary water-unit, and a new diagram of energy, which he calls the Theta-phi ($\theta\ \phi$) or temperature-entropy diagram, a graphic representation of the Carnot-Clausius fundamental principle, of which the area shows heat-units, the co-ordinates being the temperature, θ, and entropy, ϕ. He compares Regnault's experimental steam-pressures with the pressures calculated by means of his formulæ, showing closer agreement than is obtained by Regnault's most accurate formulæ.

In Mr. Paget's paper the three chief methods of making fabric or cloth or tissue from yarns or threads, viz. ordinary weaving, knitting, and what the author calls warp-weaving, are referred to. The paper describes the method by which shaped goods can be made by warp-weaving, and the machine by which this is effected. The machine, which is of a very ingenious character,

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[1] Abstract of the second lecture delivered by Mr. G. Bertin at the British Museum. Continued from p. 237.